

# **Aeolian abrasion and fine particle production from red sands: an experimental study.**

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## **Introduction**

The production of dust-sized particles ( $<100\ \mu\text{m}$ ) has been discussed at length in the literature, particularly with reference to the origins of loess deposits. The main mechanisms proposed for fine particle production are weathering, glacial grinding, fluvial comminution and aeolian abrasion and all have been identified as effective processes for producing loess-sized particles ( $20\text{--}60\ \mu\text{m}$ ; Wright *et al.* 1998). Finer particles ( $<20\ \mu\text{m}$ ) can be produced by similar mechanisms. The size, shape and composition of the sediments from which fine particles are derived has an impact upon the nature and rate of dust production. During aeolian abrasion experiments on freshly-crushed quartz, angular sand-sized particles initially yield high amounts of dust-sized material as corners and protruberances are removed. This is followed by a decrease in the production of fine particles as the grains become increasingly more rounded (Whalley *et al.* 1987; Wright *et al.* 1998).

Most natural aeolian sand grains are sub-angular to sub-rounded (Goudie & Watson, 1991) suggesting that lower quantities of fines will be yielded during abrasion compared with angular quartz. In addition, many natural dunefield sediments do not comprise 'clean' quartz grains. In particular, clay coatings on grains have been reported from a number of dunefields (e.g. Walden & White, 1997; Walker, 1979; Wasson, 1983). There has been some debate in the literature about the extent to which these clay coatings can be removed by aeolian abrasion (Walker, 1979, Wopfner & Twidale, 2001). If the clay coatings can be removed during saltation then they could provide a source of dust-sized material additional to that produced by the rounding of sand grains.

This paper investigates fine particle production by aeolian abrasion of natural dune sands featuring a clay coating. This provides three possible sources for the dust-sized material: (1) fine particles initially present in the natural sand population and released during saltation; (2) fine particles produced by spalling and chipping of larger particles; (3) fine particles derived from the removal of the clay coating from grain surfaces.

## **Method**

A series of experiments was conducted using a 'test-tube' chamber similar to that described by Whalley *et al.* (1987) and Wright *et al.* (1998) to simulate the aeolian abrasion process

(Figure 1). The sample is placed in the bottom of the glass chamber and the grains agitated by an air stream. Fine particles raised into suspension within the chamber are trapped in an electrostatic precipitator operating at 5 kV. The efficiency of this technique for trapping fine particles was estimated at 95% by Whalley *et al.* (1987).

Two main experimental runs were conducted each using 10 g of sand collected from a linear dune in western Queensland, Australia (modal grain size 172  $\mu\text{m}$ ). Clay coatings were clearly visible on the quartz grains under a light microscope and sand colour can be described as

7.5 YR 5/6 using the Munsell colour chart. For the first test 10 g of dune sand was agitated for a total of 120 hours with fine particles collected after 1, 2, 4, 8, 16, 32, 48, 72, 96 and 120 hours of abrasion. For the second test, the dune sand was acid washed using 10% hydrochloric acid followed by stannous chloride solution to remove the grain coatings (Newsome & Ladd, 1999) and then subject to the same abrasion procedure. The amount of material collected in the electrostatic precipitator was weighed after each time period. A Coulter Multisizer was used to determine the particle size distribution of the samples and the products of abrasion.

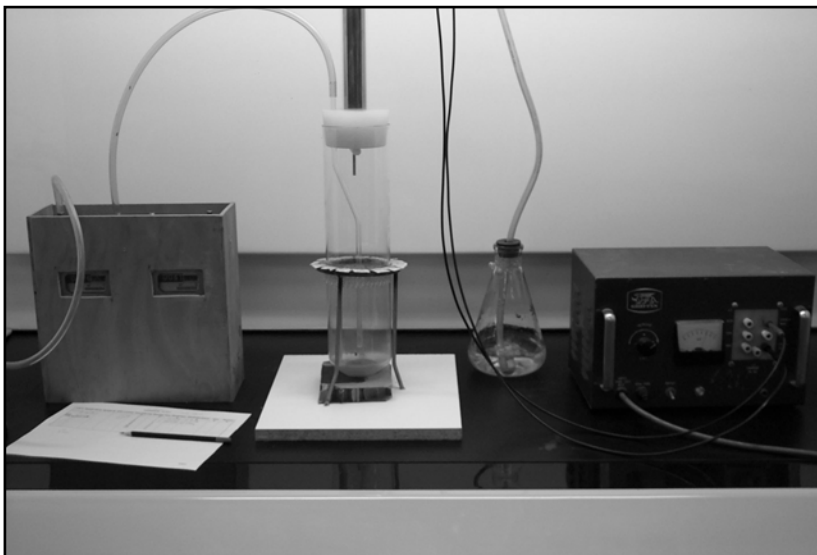


Figure 1: Abrasion apparatus used to conduct experiments. The chamber is 10 cm in diameter.

## Results and Discussion

Figure 2 shows cumulative dust production over a period of 120 hours for the natural and acid washed sand samples. The natural sand yielded a total of 0.2519 g of dust from an initial sample weight of 10.8352 g. In comparison, the acid washed sample yielded less than half that amount of fines with 0.1253 g of dust coming from 10.5304 g of sand.

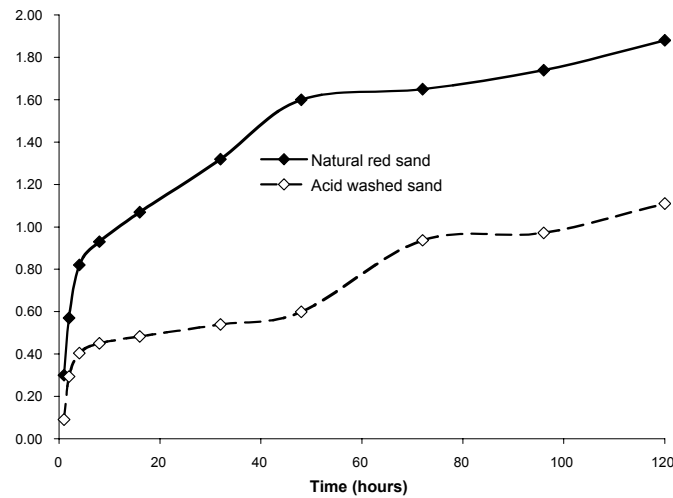


Figure 2: Weight of fine particles produced during 120 hours of abrasion expressed as a percentage of the unabraded sand sample weight.

A detailed analysis of the particle size characteristics of the fine sediments captured in the electrostatic precipitator shows that the particle size characteristics of the dusts varies during the abrasion period. Figure 3a shows the initial natural sand particle size distribution with a modal particle diameter of 172  $\mu\text{m}$ . Fines collected during the second hour of abrasion show a distinct mode at approximately 60  $\mu\text{m}$  (Figure 3b) which can be recognised in the original sand sample and probably represents small particles present in the natural sample rather than the products of abrasion. Fine particles yielded in hours 9-16 of the abrasion period show a very different particle size distribution with modes at approximately 3  $\mu\text{m}$ , 17  $\mu\text{m}$  and 40  $\mu\text{m}$  (Figure 3c). The 3  $\mu\text{m}$  and 17  $\mu\text{m}$  modes can also be recognised in the fines collected in hours 49-72 of the abrasion period (Figure 3d).

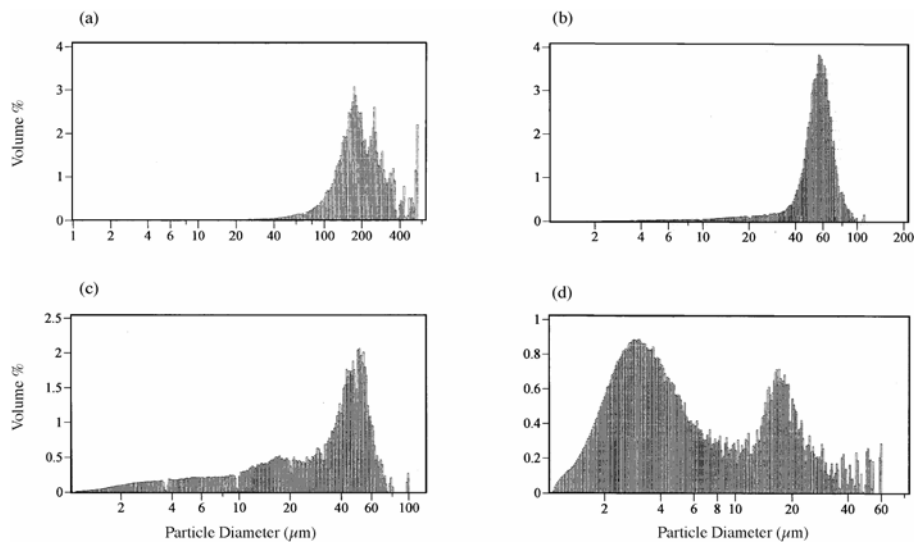


Figure 3: Particle-size distributions of unabraded natural sand sample (a) and fine particles collected after 2 hours (b), 16 hours (c) and 72 hours (d) of abrasion. N.B. scales differ.

The larger two of these modes may represent spalling and chipping of the sand grains. The finest mode may be produced from removal of the clay coatings from the outside of the grains

however more detailed analyses of the fine particle products are necessary to investigate these hypotheses further. Visual observations of the unwashed sand grains before and after abrasion did indicate a change in colour of the grains possibly caused by removal of the red clay coating. Following 120 hours of abrasion, the particle size mode of the sand sample was found to have increased to 218  $\mu\text{m}$ .

## Conclusions

Preliminary analysis of the products of abrasion in this instance suggest first that sands which are clay-coated yield greater quantities of fine particles than those from which the coatings have been removed. The particle size distribution of the fine particles produced varies through time and may be related to the abrasion process. Further investigations, including the implications for dust production and the interpretation of sediment colour are ongoing.

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